PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to the Detection of Fission Products

We, THE PLESSEY COMPANY LIMITED, a British Company of 56 Vicarage Lane, Ilford, Essex, formerly of 1 Broad Street Place, London, E.C.2, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention particularly, but not exclusively relates to systems for the detection of or the monitoring of fission products in liquid cooled nuclear reactors and in this instance is primarily concerned with the detection of delayed neutron emitting fission products which may be present in the reactor coolant stream.

It is known that in certain types of nuclear reactors the fuel elements are provided in containers which are introduced into the core of the reactor. When the containers are functioning correctly fission products are substantially wholly prevented from entering into the coolant streams of the reactors.

In the event of a rupture in one or more of the containers, fission products are able to escape into the coolant circuits of the reactor. The presence of such fission products in the coolant circuits constitutes a dangerous biological hazard. Several forms of monitoring systems have hitherto been proposed which are utilised to detect the presence of the fission products. Such monitoring systems include ion exchange resins, delayed neutron monitors, gamma detectors, Cherenkov detectors, and gaseous fission product monitors.

Detection of containment rupture is frequently made through the agency of fission products, such as Bromine 87, Bromine 89 and Iodine 137, which are delayed neutron emitters.

Coolant samples are taken from the reactor and, after a suitable delay which allows irradiation induced activity to become small, are passed through a vessel which is surrounded by a neutron moderating material. Fast high energy neutrons, produced by the decay of the fission products, pass into the moderating material and are slowed down to thermal energies. The thermal neutrons are monitored by neutron detectors suitably positioned with respect to the sample vessel and the moderating material.

The system in accordance with the invention applies to any reactor of the kind in which the reactor vessel and primary coolant circuit parts (i.e. the potentially dangerous parts) are enclosed in a secondary containment pressure vessel, which is intended to prevent the escape of dangerous radioactive products in the event of a partial or catastrophic failure of the reactor primary pressure circuit. Reactors of the kind specified include, amongst others, the marine propulsion reactors.

In reactors of the kind specified access to the inside of the secondary containment vessel is difficult or impossible under most reactor conditions, but especially when the reactor is in operation. For this reason the detection system parts which are located inside the secondary containment vessel must be very robust and require infrequent or no maintenance.

The present invention has for an object to provide an improved arrangement for monitoring a cooling mechanism in a reactor of the kind specified.

In accordance with the invention, a neutron detection arrangement is located on one side of the wall of the secondary containment vessel of the reactor, and a sample vessel for the cooling medium is located on the other side of the said wall, the vessel being separated from the detector by a part of the said wall which allows the neutrons and/or other nuclear particles to pass through the material of the wall to the detector.

For a better understanding of the invention

an application of the system in accordance with the invention will be described in greater detail in relation to an inorganic moderated reaction and in relation to the drawing accompanying the provisional specification which is a cross-sectional view through part of the wall of a reactor at a region where the detection system is installed. The reactor vessel includes a secondary containment vessel having a wall 1. A circular or other suitably shaped disc is cut from the wall 1 and the inner end of the aperture 2 which is formed by the removal of the disc is closed off in a pressure tight and fluid tight manner by a plate 3. The plate 3 is regarded as a thin window which forms a part of the containment vessel wall. Conveniently the window can be formed as a thin flat steel disc which can be for example approximately 1/16" thick. The thickness is a function of the pressure which the secondary containment vessel is required to withstand, the essential factor being that the window must be sufficiently transparent to slow moving neutrons. It will be appreciated that under other circumstances the window might be required to withstand greater pressures or for other types of monitoring systems, the windows might comprise suitably mounted pressure tight light guides or re-entrant tubes which could contain Geiger counters or some form of proportional counters. A detector means 4 for neutron or other nuclear particles is secured to the other side of the wall 1. Conveniently the detector means 4 includes an outer casing 5 which is suitably flanged as at 6 to enable the detector to be attached to the wall by bolts 7. The flange 6 is so positioned on the casing 5 that when the detector means is securely attached to the wall the innermost annular end 8 of the casing abuts or is at an extremely short distance from the adjacent surface of the window 3. The innermost end 8 of the casing is closed off by a thin metallic window 9 whereby the innermost end of the casing is sealed off in a fluid and air tight manner. The metallic window also provides a light tight unit. Inside the detector casing there is provided a photo-multiplier tube 10 the window 11 of which faces towards the thin metal window 9. A light guide 12 and a scintillator unit 13 are interposed between the window 9 of the detector casing and the window of the photo - multiplier tube 10. The scintillator or phosphor unit 13 comprises a methyl - methacrylate disc which is grooved on the face adjacent to the thin window 9. The grooved surface provides a chamber which is filled with a mixture of boron 10 and zinc sulphide (ZnS). The boron 10 acts as the primary slow neutron detector. When the slow neutrons enter the mixture, they are captured by boron atoms which then disintegrate producing lithium 7 and an alpha particle with the energy of 2.8 MeV. The alpha particle reacts on the zinc sulphide to produce a small scintillation or impulse of visible light. These light impulses pass through the disc 13, through the light guide 12 which latter also provides an additional moderator for epithermal neutrons and enters the windows of the photo-multiplier tube 10. The latter is a multi-stage photoelectric device which converts the light pulses into electric pulses and provides a considerable amplification of the original electrical signal produced by the light pulses entering the window of the photomultiplier tube.

Immediately adjacent to the other side of the window 3 there is provided a block 14 of a moderating material, that is a material which is capable of slowing down fast neutrons. Carbon, hydrogen and deuterium are notably good moderators and a chemical combination such as water, heavy water and many organic compounds are also very effective, the latter including various waxes and polythene etc.

The block 14 of moderating material is surrounded by a further block 15 of moderating material. A sample vessel 17 is in a bore formed in a similar block 16, the inner end 18 of the sample vessel being adjacent to the face 19 of the block 15 of moderating material whereby it effectively lines up with the thin walled window 3 in the containment wall. The sample vessel 17 is surrounded by a heating coil 20 the purpose of which will be described hereinafter. An inlet duct 21 leads the coolant fluid of the reactor, of which it is desired to measure the neutron content into the sample vessel 17, which it then leaves via outlet conduit 22. Baffles 23 are provided to ensure that the fluid travels across the end 18 of the sample vessel 17. Since the coolant fluid which is used in the reactor will be at a relatively high temperature for example at temperatures of the order of 300° C., it is necessary to interpose a thermal insulating means between the sample vessel and the moderator material. Conveniently this thermal insulating means can comprise an insulating sandwich 29 consisting of a layer of fibre glass 24 arranged between two aluminium sheets 25 and 26, and a cooling air flow duct 27 is located between the sheet 26 and a further aluminium sheet 28. This arrangement is intended to prevent the transfer of heat from the sample vessel to the moderator materials and the counter assembly. The apparatus operates as follows. The coolant material which is presumed to carry the fission products is introduced into the sample vessel 17 and whilst it is in the sample vessel fast neutrons or other nuclear particles escape from the fluid with a random distribution into the surrounding blocks 15 and 16 of moderating materials. These moderating materials, as previously mentioned, slow down the fast neutrons to thermal energies in which state they may be

detected by the detector means. The neutrons actually detected are those which pass into the phosphor unit 13 and thence into the window of the photo-multiplier tube 10.

The heating coil 20 is used during the starting-up of the reactor if a normally wax-like coolant is employed to melt the coolant in the sample vessel and thus enable the circuit to flow.

WHAT WE CLAIM IS:—

1. An arrangement for monitoring a cooling medium within a nuclear reactor of the kind specified, wherein a neutron detection arrangement is located on one side of the wall of the secondary containment vessel of the reactor, and a sample vessel for the cooling medium is located on the other side of the said wall, the vessel being separated from the detector by a part of the said wall which allows the neutrons and/or other nuclear particles to pass through the material of the wall to the detector.

2. An arrangement as claimed in claim 1, wherein the said part of the wall of the containment vessel includes a metal window.

3. An arrangement as claimed in claim 1 or 2, wherein the detector is readily removable from its operational position, and hermetically sealed by a window transmissive to the neutrons or other nuclear particles.

4. An arrangement as claimed in claim 1, 2 or 3, wherein the detector unit includes a phosphor unit and a photo-multiplier tube.

5. An arrangement as claimed in any one of the preceding claims, wherein the sample vessel is thermally insulated from the wall.

6. An arrangement as claimed in claim 5, wherein the thermal insulation means includes a fibre-glass layer and an air duct through which cooling air can be caused to flow.

7. An arrangement for monitoring the cooling medium within a nuclear reactor of the kind specified, substantially as hereinbefore described with reference to the drawing accompanying the provisional specification.

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For the Applicants.

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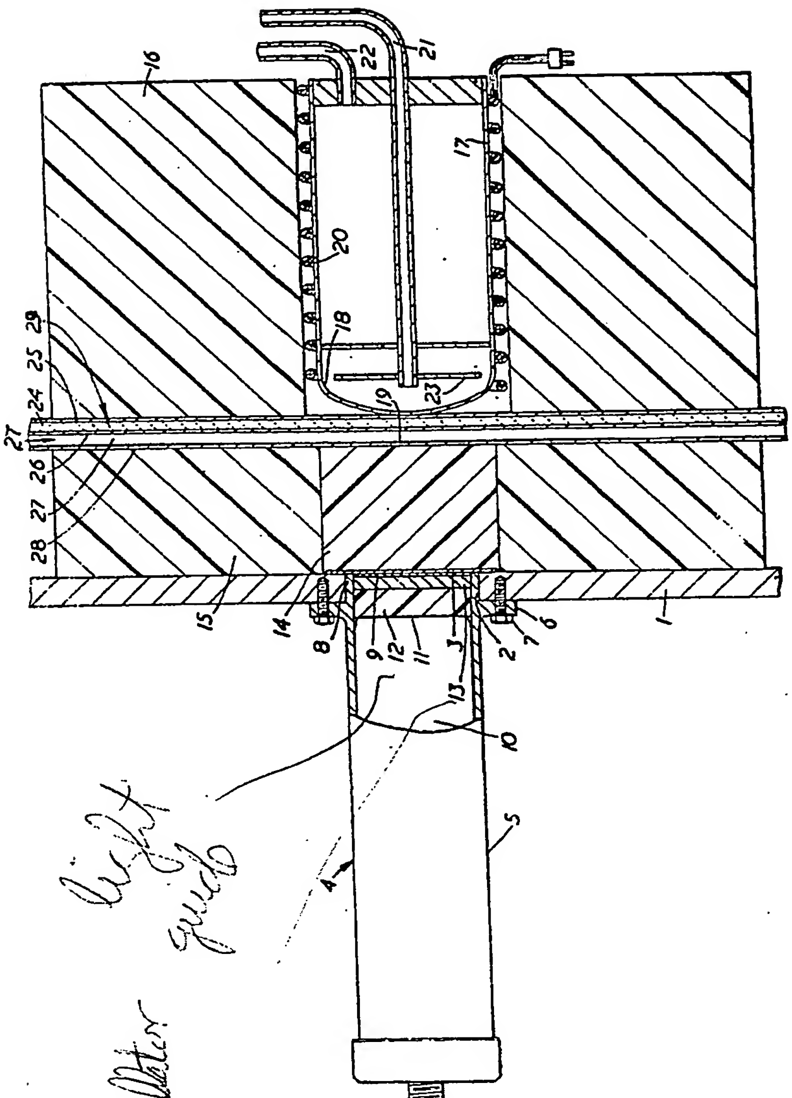
PROVISIONAL SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale



light guide

scintillator